*भारतीय मानक*
*Indian Standard*

**IS 17107 : 2019**

# सघन एवं तापअवरोधी फायर्ड रिफेक्ट्रीज, मोनोलिथिक एवं प्रीकास्ट प्रीफायर्ड (पी सी पी एफ) आकृतियों के रिफेक्ट्रीज की उष्मीय चालकता ज्ञात करने की पद्धति

# Method for Determination of Thermal Conductivity of Dense as Well as Insulating Fired Refractories, Refractory Monolithics and Precast Prefired (PCPF) Shapes

ICS 81.080

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Refractories Sectional Committee, MTD 15

## FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Refractories Sectional Committee had been approved by the Metallurgical Engineering Division Council.

This standard is intended to be used for assessment of the thermal conductivity of dense and insulating fired refractories, refractory monolithics and precast prefired (PCPF) shapes as well as for checking their conformity to the specifications.

In reporting the result of a test or analysis made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'.

*Indian Standard*

# METHOD FOR DETERMINATION OF THERMAL CONDUCTIVITY OF DENSE AS WELL AS INSULATING FIRED REFRACTORIES, REFRACTORY MONOLITHICS AND PRECAST PREFIRED ( PCPF ) SHAPES

## 1 SCOPE

This standard covers the method for determining the thermal conductivity of Dense and Insulating refractories by the water calorimetric method.

## 2 REFERENCES

The standards listed below contain provisions which through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subjects to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

| *IS No.* | *Title* |
|---|---|
| 1528 (Part 12) : 2007/ ISO 5016 : 1997 | Methods of sampling and physical tests for refractory materials: Part 12 Method for determination of bulk density and true porosity of shaped insulating refractory products (*second revision*) |
| 10570 : 2011 | Methods for testing refractory castables ( *first revision*) |

## 3 APPARATUS

The arrangement of the apparatus, consisting of the following essential parts, is illustrated in Fig. 1. The details of each component are given below:

a) *Heating chamber*, with removable top lid lined with insulating bricks and capable of holding the electric heater, the calorimeter, test sample, silicon carbide (SiC) slab and thermocouples. The SiC slab shall be slightly larger than the test sample so as to cover the latter completely when assembled in the heating chamber. Suitable heating furnace, capable of heating the chamber up to 1 200°C and adjustable to within 5°C of the test temperature.

b) *Calorimeter,* made of copper having one inlet and one outlet water connection, connected to the water supply system, capable of water flow rates of 120 - 200 ml/min.

c) *Water supply system*, overhead tank capable of maintaining a constant rate of water flow through the calorimeter within 1 percent during the test period at a constant height of at least 3 meter and a temperature not changing at a rate greater than 0.5°C/h. The inlet temperature of water to this tank shall be within ± 2°C of the room temperature.

d) *Thermocouples*, suitable calibrated thermocouples embedded in the test specimen at two points for measuring temperature. The thermocouples shall be connected to temperature indicators of sensitivity 1°C.

e) *Thermometers, f*or measuring the water temperatures at the calorimeter inlet and outlet, sensitivity 0.5°C.

f) *Measuring cylinder*, capacity 250 ml for collecting water from the calorimeter.

g) *Weighing balance*, capacity 500 g accuracy 0.5 g.

h) *Brick cutting machine*, drilling machine with drilling jig as required.

j) *Vernier caliper*, graduated to 0.02 mm.

k) *Stop watch*, graduated to 0.5 s.

## 4 TEST SAMPLES

### 4.1 Bricks and Shapes

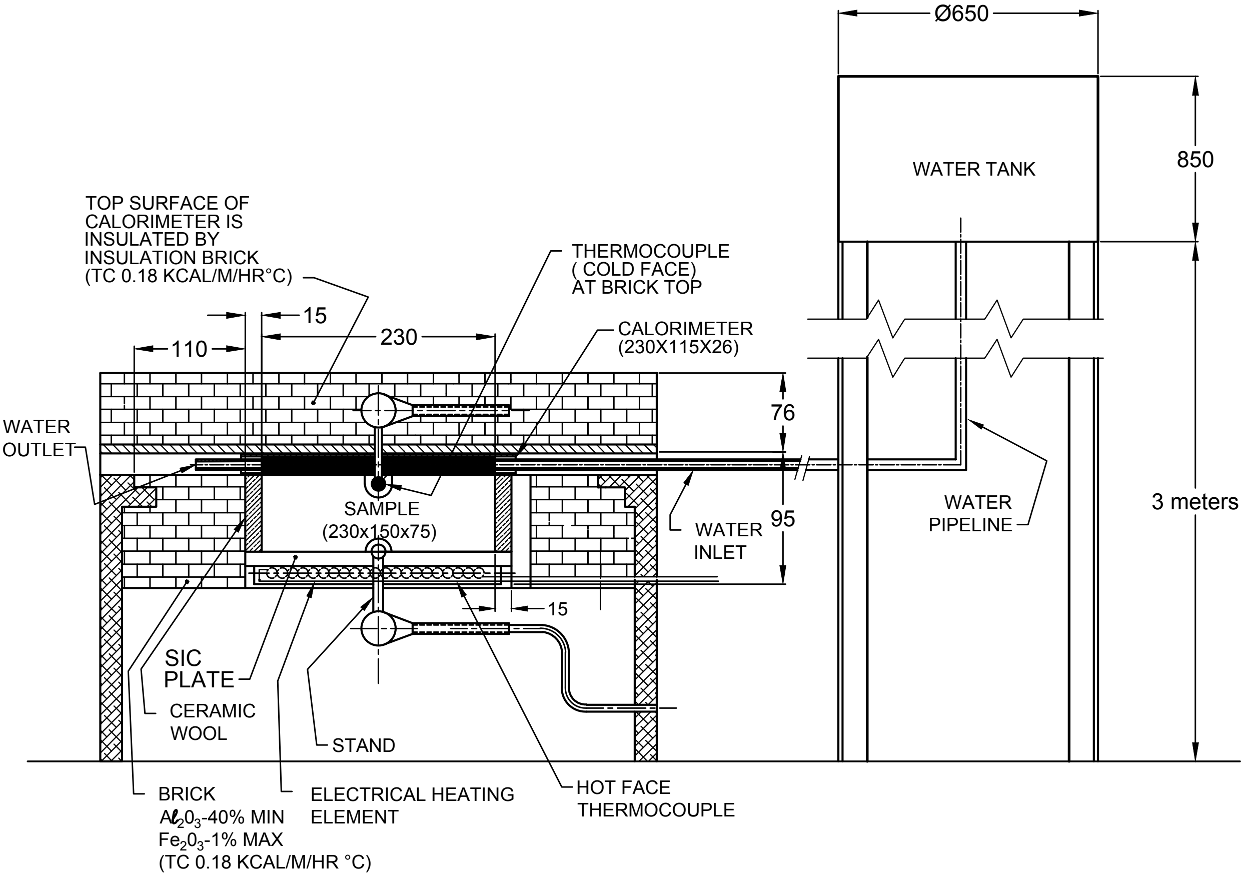
The test sample shall consist of one straight brick of nominal size 230 mm × 115 mm × 75 mm or 230 mm × 115 mm × 65 mm, which is representative of the lot being tested. The sample shall be uniform in structure and free from broken corners and edges. Oven dry the sample at 110 ± 5°C till constant weight.

### 4.2 Monolithic Refractories

The test sample shall consist of one straight brick of nominal size 230 mm × 115 mm × 75 mm or 230 mm × 115 mm × 65 mm prepared, cured and dried in accordance with IS 10570. Prefire the sample at the applicable temperature and cool. Prefiring temperature for:

a) Insulating castable — 500 ± 10°C or test temperature, whichever is higher for 3 h soaking.

b) Dense castable — 800 ± 10°C or test temperature, whichever is higher for 3 h soaking.



All dimensions are in millimetres.

FIG. 1 OVERALL ARRANGEMENT OF DIFFERENT COMPONENTS OF THE WATER CALORIMETER

### 4.3 Preparation of Test Sample

The 230 × 115 mm faces of the sample shall be flat and parallel and the thickness shall not vary by more than ± 0.3 mm. Grind the faces, if required cut a groove at the centre of each 230 × 115 mm face, from one edge to the centre point along the 115 mm dimension. The grooves for the hot and cold faces shall run in opposite direction. The width and depth of the groove shall be 1 mm larger than the diameter of the thermocouple tube so as to house thermocouple just below the surface of the sample.

Measure the eventual distance between the centre lines of the hot and cold face thermocouples accurately to 0.02 mm. Round off to 0.1 mm and record in cm. This shall be done by measuring the thickness of the brick at the location of the thermocouple and deducting the distance between the centre line of each thermocouple in its embedded position and the surface of the brick.

## 5 BULK DENSITY

Determine the bulk density of the test sample by the direct measurement method in accordance with IS 1528 (Part 12) and record the result in gm/cm$^3$.

## 6 SET UP OF TEST SAMPLE

Insert the electric heater into the heating chamber followed by the SiC slab. Place the test sample on the SiC slab and insert thermocouple into the grooves. Fix the thermocouple into position by packing the grooves/holes with refractory powder / fiber. Place the calorimeter on the sample and fill in gaps between the heating chamber and the sample with ceramic wool. Place insulating firebricks all around the calorimeter and fill the vacant area thus formed over the calorimeter, with ceramic wool. Finally cover the assembly with the lid. The details of the test specimen arrangement in the instrument are given in Fig. 2.

## 7 PROCEDURES

**7.1** Start water flow through the calorimeter and switch on the heater. Maintain the rate of water flow between 120 - 200 ml/min with the help of the control valve and determine it by weighing the quantity of water collected over a measured period of time. The mass of water collected shall not be less than 200 g and shall be weighed to an accuracy of 0.5 g. The rate of flow shall be constant within 1 percent during the test period.

**7.2** Allow the furnace to reach the state of equilibrium at the test temperature, which is that condition when the measured flow of heat into the calorimeter varies less than 2 percent over 2 h period and the hot face temperature of the test specimen has not varied more than ± 2°C. Also the temperature of water entering the calorimeter has not varied more than ± 2°C. Usually 2-3 h is needed to attain equilibrium after a definite change is made in the hot face temperature.

**7.3** After the equilibrium stage has been reached measure the hot and cold face temperature of the sample, the rate of water flow through the calorimeter and the temperature rise of the water flowing through the calorimeter. Take at least three sets of readings at approx 30 min intervals during the 2 h holding period.

**7.4** At the end of the test, remove the sample and cut it in two, at the thermocouple grooves. If the sample shows abnormal internal voids or cracks state this fact in the report.

## 8 CALCULATION

$$k = \{m \times 60\ (t_2 - t_1) \times d\} \ / \ \{A \times (t_h - t_c) \times 10\}$$

where,

$k$ = thermal conductivity of test sample, in kcal/mh°C;

$m$ = water flow rate through calorimeter, in g/min;

$t_2$ = water temperature at calorimeter outlet, in °C;

$t_1$ = water temperature at calorimeter inlet, in °C;

$d$ = distance between thermocouple centre lines, in cm;

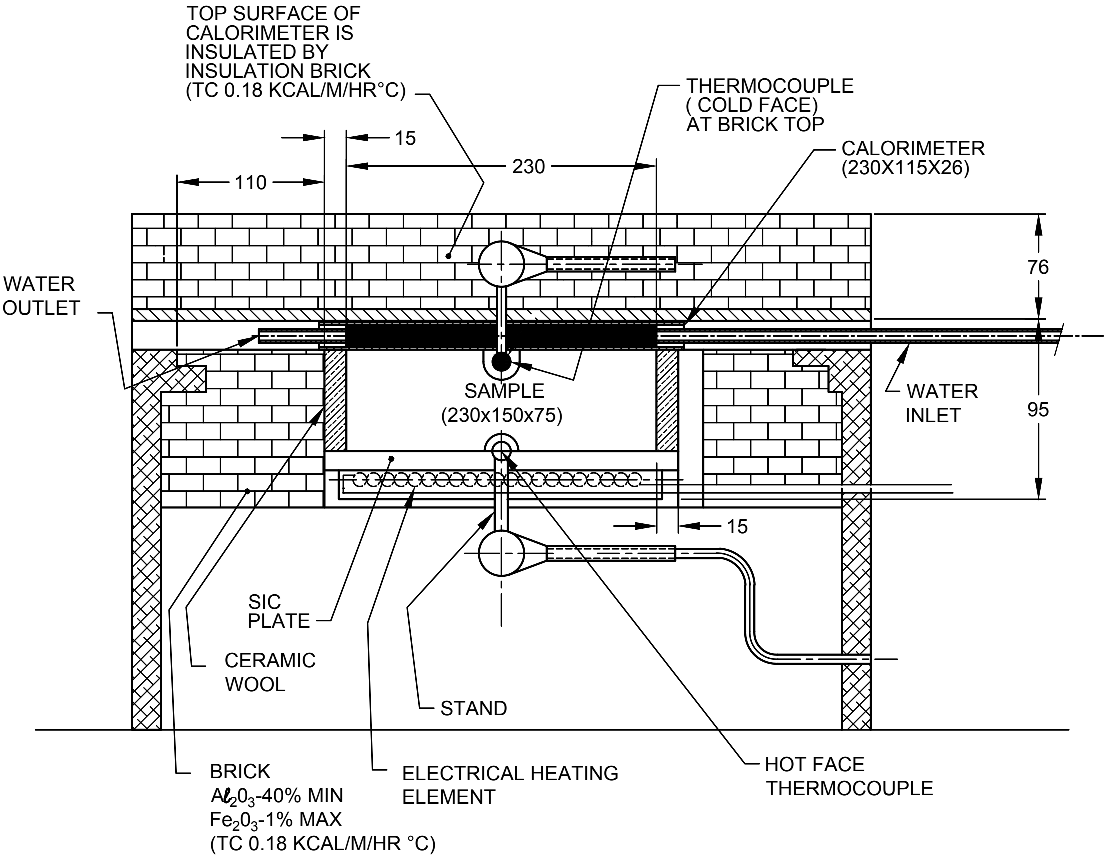
$A$ = area of calorimeter (22.96 × 11.25 = 258.30), in $cm^2$;

$t_h$ = hot face temperature of test sample, in, °C; and

$t_c$ = cold face temperature of test sample, °C.

## 9 REPORT

Report the average of three individual conductivity values rounded off to two places of decimal. If upon being cut the sample show abnormal internal voids or cracks state this fact in the report.



All dimensions are in millimetres.

FIG. 2 ARRANGEMENT OF THE REFRACTORY

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## Amendments Issued Since Publication

| Amend No. | Date of Issue | Text Affected |
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